

NDLA 3116-3 and NDLA 3104-4: new high yielding cultivars of Asiatic cotton (*Gossypium arboreum* L.)

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Abstract: *Gossypium arboreum* varieties NDLA 3116-3 and NDLA 3104-4 have mean seed cotton yield potential of 1257 kg ha⁻¹ in central zone and 928 kg ha⁻¹ in southern zone, respectively and are released for commercial cultivation in the respective zones of India by Regional Agricultural Research Station, Nandyal, India.

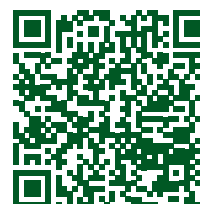
Keywords: *G. arboreum*, *Desi cotton*, *seed cotton yield*


INTRODUCTION

Cotton (*Gossypium* spp.) is an important fiber crop that is predominant in the agricultural economy. It is cultivated in approximately 3% of the world's arable land (Reddy et al. 2022). Globally, cotton is cultivated in an area of 33.1 m ha with production and productivity of 25.73 m tons and 775 kg ha⁻¹, respectively (International Cotton Advisory Committee data portal 2021/22) (ICAC 2022). In India, the cotton area is 12.5 m ha with production and productivity of 5.66 m tons and 441 kg ha⁻¹, respectively (AICRP on Cotton 2023/24). The genus *Gossypium* consists of four cultivated species, namely *G. hirsutum*, *G. barbadense*, *G. arboreum* and *G. herbaceum*. In India, *G. arboreum* occupies approximately 0.1 m ha mostly concentrated in the Punjab, Haryana and Rajasthan states in North India, Madhya Pradesh and Maharashtra in Central India and Andhra Pradesh and Karnataka states in Southern India. *G. arboreum* exhibits inherent tolerance to drought, pests and diseases and can grow under low input management conditions (Tahir et al. 2021). Thus, the cultivation of *G. arboreum* varieties promises ecological sustainability in agriculture and reduces the cost of cultivation by 30-40% in irrigated and 10-25% in rainfed areas compared to the cultivation of *G. hirsutum* varieties/hybrids in India (Subramanian 2023). Further, the demand for the cultivation of *G. arboreum* varieties is increasing, but the demand is lagging due to the lack of varieties with high-yielding and desirable fiber traits.

The Regional Agricultural Research Station, Nandyal, has been working on *G. arboreum* since 1906 to develop high-yielding varieties adaptable to rainfed agricultural conditions. The variety NDLA 2933 was released in the year 2010 and has a mean seed cotton yield potential of 750 kg ha⁻¹, staple length of 21 mm and bundle strength of 22.7 g tex⁻¹. However, to improve productivity, it

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is necessary to develop cultivars with high-yielding, superior fiber traits and tolerance to pests and diseases. Keeping the importance of *G. arboreum* cotton in the Indian rainfed farming system, the study was undertaken to develop high-yielding varieties with desirable fiber traits. Here, we report the two varieties, namely NDLA 3116-3 (Nandyal Arboreum 3116-3) and NDLA 3104-4 (Nandyal Arboreum 3104-4), released for commercial cultivation in central and southern zones, respectively, in India.

BREEDING METHOD

NDLA 3116-3 and NDLA 3104-4 arose from the crosses NDLA 2933 × ARBa 79-08 and NDLA 2708 × CINA 357, respectively followed by a pedigree method of selection at the Regional Agricultural Research Station, Nandyal, India. The parental lines of varieties have notable traits like NDLA 2933 and NDLA 2708 are high yielders, ARBa 79-08 is a dwarf type with 70-90 cm plant height and CINA 357 has high staple length of 26.5 mm. The crosses between the parental lines were carried out in the *Kharif* season of 2009-2010 and the F₁ seed of respective crosses was sown in 2010-2011. The evaluation of F₂ material was done during 2011-2012 and selections were made based on seed cotton yield, fiber traits and tolerance to pests and diseases. The selection in F₂ plants gives rise to F₃ families, which subsequently formed the F₄ and F₅ plants. The evaluation and individual plant selections of F₃, F₄ and F₅ generations were carried out during 2012-2013, 2013-2014 and 2014-2015, respectively. The seeds of F₅ selected plants formed the observational yield trial (OYT) in 2015-2016.

The OYT was conducted in the years 2015-2016 and 2016-2017 for the variety NDLA 3116-3 and in the year 2015-2016 for NDLA 3104-4. The preliminary yield trials (PYT) were conducted in the years 2017-2018 and 2016-2017 for NDLA 3116-3 and NDLA 3104-4, respectively. The advanced yield trials (AYT) were conducted in the year 2018-2019 for NDLA 3116-3 and in the years 2017-2018 (AYT1) and 2018-2019 (AYT2) for NDLA 3104-4. Further, both varieties were evaluated in All India Coordinated Cotton trials at various locations in India from 2019-2020 to 2021-2022. The PYT, AYT and coordinated trials were conducted in the randomized block design with three replications and the data was collected for seed cotton yield, lint yield, ginning out turn, bolls per plant, boll weight and Upper half mean length (UHML). The entries were sown in a plot size of 5.0 × 3.0 m² with inter and intra-row spacing of 0.6 m and 0.3 m, respectively. The agronomic evaluation of both varieties was completed in the year 2022-2023 in rainfed *G. arboreum* cultivating locations in India. The varieties NDLA 3116-3 and NDLA 3104-4 showed high seed cotton yield with superior fiber traits, and tolerance to pests and diseases and were suitable for cultivation under rainfed conditions of central and southern zones, respectively in India. Based on the performance of varieties in multilocation coordinated trials, the varieties NDLA 3116-3 and NDLA 3104-4 were identified for central and southern zones of India, respectively by the Central Varietal Release Committee on 31st July 2023 and notified by The Gazette of India, Extraordinary (PART II-Section 3 – Sub-section (ii)) S.No. 198 and 199 on 26th March 2024.

TRAITS AND PERFORMANCE

The distinguishing characteristics of the varieties NDLA 3116-3 and NDLA 3104-4 as per the Distinctness, Uniformity, and Stability (DUS) guidelines were presented in Table 1. The plant habit of both varieties is lanky, stem hairy and dust green. The plant height ranges from 110 to 115 cm and from 115 to 120 cm for the varieties NDLA 3116-3 and NDLA 3104-4, respectively. The maturity of the varieties is medium type with approximately 150 days from seed to seed. The leaf is digitate, green and medium hairy type. The petal color is cream with yellow pollen having petal spot. The bolls are small to medium with oval shape for both varieties. The fuzz of the varieties is the medium type with a white color. The fiber of the varieties has medium staple length and strength with fair uniformity and good maturity percentage.

The mean seed cotton yields of varieties NDLA 3116-3 and NDLA 3104-4 were 1936 kg ha⁻¹ and 1811 kg ha⁻¹ in station (OYT, PYT and AYT) trials (Table 2). The mean seed cotton yield over the three years of testing of the varieties NDLA 3116-3 and NDLA 3104-4 was 1257 kg ha⁻¹ in the central zone and 928 kg ha⁻¹ in the southern zone, respectively (Table 3). The mean seed cotton yield of variety NDLA 3116-3 is 4% and 27% higher than those of the local check and zonal check, respectively in the central zone, whereas the value of the variety NDLA 3104-4 is 21% and 26% higher than those of the local check and zonal check, respectively in the southern zone of India. The mean lint yields of varieties NDLA

3116-3 and NDLA 3104-4 are 482 kg ha⁻¹ in the central zone and 337 kg ha⁻¹ in the southern zone, respectively. The mean UHML of the varieties was 22.8 mm for NDLA 3116-3 and 21.9 mm for NDLA 3104-4 in the central and southern zones, respectively (Table 4). Based on the full spinning test, the bundle strength of the varieties was found to be 24.9 g tex⁻¹ for NDLA 3116-3 in the central zone and 24.0 g tex⁻¹ for NDLA 3104-4 in the southern zone of India (Table 5).

Table 1. Distinguishing characteristics of the varieties NDLA 3116-3 and NDLA 3104-4 as per the DUS guidelines

Plant character	Description and code (score) according to DUS guidelines	
	NDLA 3116-3	NDLA 3104-4
Leaf: Color	Green (2)	Green (2)
Leaf: Hairiness	Medium (5)	Medium (5)
Leaf: Nectaries	Present (9)	Present (9)
Leaf: Shape	Digitate (3)	Digitate (3)
Plant: Stem hairiness	Medium (5)	Medium (5)
Flower: Petal color	Cream (2)	Cream (2)
Flower: Petal spot	Present (9)	Present (9)
Flower: Stigma	Exserted (5)	Exserted (5)
Flower: Pollen color	Yellow (9)	Yellow (9)
Boll: Color	Green (3)	Green (3)
Boll: Shape (longitudinal section)	Ovate (5)	Ovate (5)
Boll: Surface	Smooth (9)	Smooth (1)
Boll: Weight of seed cotton/boll (g)	Medium (5)	Medium (5)
Seed: Fuzz	Medium (5)	Medium (5)
Seed: Fuzz color	White (1)	White (1)
Seed: Index (100 seed weight) (g)	Medium (5)	Medium (5)
Ginning percentage	High (7)	High (7)
Fiber: Color	White (1)	White (1)
Fiber: Length (UHML) (mm)	Medium (3)	Medium (3)
Fiber: Strength (g/tex)	Medium (5)	Medium (5)
Fiber: Fineness (Micronaire)	Very coarse (1)	Very coarse (1)
Fiber: Uniformity	Fair (3)	Fair (3)
Fiber: Maturity (%)	Good (7)	Good (7)

DUS – Distinctness, Uniformity, and Stability (https://www.cicr.org/in/pdf/dus_test_manual.pdf), a Training manual on DUS test in cotton with reference to PPV & FR legislation, 2001. The values in parenthesis indicate the notes (1 to 9) used to describe the state of each character for digital data processing, and these notes are given against the states of each characteristic.

Table 2. Seed cotton yield and its attributing traits data of varieties NDLA 3116-3 and NDLA 3104-4 compared to local check (LC) in Observational yield trial (OYT), Preliminary yield trial (PYT) and Advanced yield trial (AYT) at RARS, Nandyal

Traits	Trials	Varieties				Traits	Varieties			
		NDLA 3116-3	LC	NDLA3104-4	LC		NDLA 3116-3	LC	NDLA3104-4	LC
Seed cotton yield (kg ha ⁻¹)	OYT	2875	945	375	125	Bolls per plant	51	36	12	12
	PYT	1550	1039	3815	2787		16	14	60	59
	AYT	1384	1237	1244	986		20	22	15.5	17
	Mean	1936	1074	1811	1299		29	24	29.2	29
Lint yield (kg ha ⁻¹)	OYT	1193	308	135	44	Boll weight (g)	3.6	2.6	1.4	2.2
	PYT	640	404	1297	1003		2.7	2.3	2.7	2.5
	AYT	555	448	434.5	365.5		2.7	2.1	2.3	2.0
	Mean	796	387	622	471		3.0	2.3	2.1	2.2
Ginning outturn (%)	OYT	41.5	32.6	36	35	UHML (mm)	18	19	18	22
	PYT	41.3	38.9	34	36		18	21	18	21
	AYT	40.1	36.2	34.9	37		20	23	19	23
	Mean	40.9	35.9	34.9	36		18	21	18	22

The local check used was NDLA 2933 in all the trials at the Regional Agricultural Research Station (RARS), Nandyal

Table 3. Average seed cotton yield (kg ha⁻¹), Average lint yield (kg ha⁻¹), mean ginning outturn (%), mean bolls per plant, mean boll weight (g) of varieties NDLA 3116-3 and NDLA 3104-4 compared to local check (LC) and zonal check (ZC) in AIC trials

Traits	Years	Central zone			Southern zone		
		NDLA 3116-3	LC	ZC	NDLA 3104-4	LC	ZC
Seed cotton yield (kg ha ⁻¹)	2019-20	1847a	1608a	1219b	1668	1409	1428
	2020-21	782	780	790	560a	255b	261b
	2021-22	1142a	1238a	966b	555	638	522
	Mean	1257a	1209a	992b	928a	767b	737b
Lint yield (kg ha ⁻¹)	2019-20	724	558	472	612	504	523
	2020-21	287	264	291	196a	89b	91b
	2021-22	435	444	371	202	221	179
	Mean	482a	422b	378c	337a	271b	264b
Ginning outturn (%)	2019-20	38.9a	34.5a	37.7a	36.8a	35.2b	36.6a
	2020-21	36.6a	34.1b	36.9a	36.1	35.1	34.8
	2021-22	33.3	31.7	33.6	36.0	35.0	34.0
	Mean	36.3a	33.4b	36.1a	36.5a	35.2b	35.7b
Bolls per plant	2019-20	30.4a	29.3a	23.7b	13.9	13.3	13.3
	2020-21	22.2	23.8	21.8	8.0a	4.6b	4.8b
	2021-22	22.8	23.0	22.0	12.5a	14.9b	12.3a
	Mean	25.1a	25.4a	22.5b	11.5a	10.9a	10.1b
Boll weight (g)	2019-20	2.5	2.5	2.5	2.5	2.5	2.5
	2020-21	2.4a	2.2b	2.2b	2.1a	1.9b	1.8b
	2021-22	2.4a	2.5c	2.3b	2.9a	2.8a	2.4b
	Mean	2.4a	2.4a	2.3b	2.5a	2.4a	2.2b

The local checks used were AKA 8 and NDLA 2933 in the central and south zones, respectively. The zonal checks used were AKA 7 and DLSa 17 in the central and south zones, respectively. The entries were evaluated in Khandwa, Amreli, Akola, Parbhani, Jalgaon and Nagpur locations in the central zone and Dharwad, Nandyal, Mudhole and Kovilpatti locations in the south zone of India. Means with the same letter in the row are not significantly different by t-test.

Table 4. Fiber quality data of varieties NDLA 3116-3 and NDLA 3104-4 compared to local check (LC) and zonal check (ZC) in AIC trials in central and south zones

Traits	Years	Central zone			Southern zone		
		NDLA 3116-3	LC	ZC	NDLA3104-4	LC	ZC
UHML (mm)	2019-20	23.3a	26.7b	24.9c	22.2a	25.4b	27.5c
	2020-21	23.9a	25.7b	25.1b	21.0a	24.7b	24.8b
	2021-22	21.3a	25.4b	24.4c	22.6a	25.6b	27.2c
	Mean	22.8a	25.9b	24.8b	21.9a	25.2b	26.5c
Micronaire (µg inch ⁻¹)	2019-20	6.1a	5.2b	5.2b	6.4a	5.8b	5.1c
	2020-21	6.3a	5.3b	5.6b	6.5a	5.5b	5.2b
	2021-22	6.5a	5.3b	5.5b	6.7a	5.6b	5.0c
	Mean	6.3a	5.3b	5.4b	6.5a	5.6b	5.1c
Bundle strength (g tex ⁻¹)	2019-20	23.8ab	28.5a	25.6b	22.4a	25.1b	25.2b
	2020-21	24.3	26.4	25.3	20.5a	22.8b	23.3c
	2021-22	21.4a	25.7b	25.3b	21.5a	25.7b	25.6b
	Mean	23.2a	26.9b	25.4c	21.5a	24.5b	24.7b
Uniformity index	2019-20	78.6a	81.8b	81b	79a	82.5b	82.5b
	2020-21	80.5a	83.2b	82c	79a	82b	80a
	2021-22	79.5a	82.5b	80a	79a	82.5b	81.5b
	Mean	79.5a	82.5b	81c	79a	82.3b	81.3b
Elongation %	2019-20	5.7a	6.2b	6.2b	5.8a	6.8b	6.9b
	2020-21	5.5	5.7	5.6	5.8a	6.2b	6.1b
	2021-22	5.7	5.6	5.6	5.8a	6.3b	6.5b
	Mean	5.6	5.8	5.8	5.8a	6.4b	6.5b

The local checks used were AKA 8 and NDLA 2933 in the central and south zones, respectively. The zonal checks used were AKA 7 and DLSa 17 in the central and south zones, respectively. The entries were evaluated in Khandwa, Amreli, Akola, Parbhani, Jalgaon and Nagpur locations in the central zone and Dharwad, Nandyal, Mudhole and Kovilpatti locations in south zone of India. Means with the same letter in the row are not significantly different by t-test.

The varieties NDLA 3116-3 and NDLA 3104-4 recorded the mean jassid injury grade of one in central and southern zones, respectively (Table 6). The data on other sucking pests infestation recorded the jassid/3 leaves of 5.95 and 2.78, whiteflies/3 leaves of 12.9 and 0.53 and aphids/3 leaves of 14.27 and 5.5 for NDLA 3116-3 in the central zone and NDLA 3104-4 in the southern zone, respectively. The variety NDLA 3104-4 recorded the thrips/3 leaves of 0.58 in the southern zone of India. The scoring data on reaction to different diseases of variety NDLA 3116-3 showed 3.3 for bacterial leaf blight caused by *Xanthomonas citri* pv. *malvacearum*, 17.9 for *Alternaria* leaf spot caused by *Alternaria* spp. and 6.7 for gray mildew caused by *Ramularia areola* and no reaction for rust caused by *Phakospora gossypii* in the central zone. In turn, the variety NDLA 3104-4 showed no reaction for bacterial leaf blight, 14.9 for *Alternaria* leaf spot, 17 for gray mildew and 21 for rust in the southern zone of India (Table 7). Further, the calculation of Area Under Disease Progress Curve (AUDPC) values gave 100% accuracy for the tolerance behavior of varieties for particular diseases. Overall, the new varieties recorded the tolerance to on par reaction for the sucking pests and diseases in the respective zones of India.

MOLECULAR BACKGROUND

The genetic profile of the varieties NDLA 3116-3 and NDLA 3104-4 were studied in comparison with the control samples using 18 simple sequence repeat primers at the Division of Genomic Resources, National Bureau of Plant Genetic Resources, New Delhi, India. The primers JESPR-197, MUCS-443, BNL-4071, BNL-2634, BL-530, JESPR-101, BNL-285, BNL-834, NAU-980 and NAU-1190 were polymorphic and able to differentiate the two varieties for other cotton genotypes.

Table 5. Fiber quality characteristics of varieties NDLA 3116-3 and NDLA 3104-4 based on full spinning test

Varieties	Zones	Locations	UHML (mm)	UI	Mic	Str (g tex ⁻¹)	E (%)	Count 1	CSP1	Count 2	CSP2
NDLA 3116-3	Central	Akola	23.5	81	6.2	24.9	5.7	12s	1857	16s	1699
NDLA 3104-4	South	Dharwad	22.6	79	6.8	24.0	5.5	12s	1553	-	-

Table 6. Reaction of varieties NDLA 3116-3 and NDLA 3104-4 to different sucking pests compared to local check (LC) and zonal check (ZC) in AIC trials

Traits	Years	Central zone			Southern zone		
		NDLA 3116-3	LC	ZC	NDLA 3104-4	LC	ZC
Jassid injury grade	2019-20	1	1	1	1	1	1
	2020-21	1	1	1	1	1	1
	2021-22	-	-	-	1	1	1
	Mean	1	1	1	1	1	1
Jassid/3 leaves	2019-20	12.5a	15.0b	11.0a	1.72a	2.6b	2.6b
	2020-21	2.15a	0.95b	2.35a	2.13a	1.93b	1.85c
	2021-22	3.2	2.93	3.0	4.5a	4.0b	5.4c
	Mean	5.95a	6.29b	5.45a	2.78a	2.84a	3.28b
White flies/3 leaves	2019-20	12.5	13.0	15.0	0a	0.3b	0a
	2020-21	14.5	13.8	13.0	1.06a	0.97b	1.02a
	2021-22	11.6a	8.6c	10.0b	-	-	-
	Mean	12.9	11.8	12.7	0.53a	0.63b	0.51a
Thrips/3 leaves	2019-20	-	-	-	4.5a	3.0c	4.0b
	2020-21	-	-	-	18.1a	18.3a	16.3b
	2021-22	-	-	-	20.2a	8.79b	19.79a
	Mean	-	-	-	14.27a	10.03b	13.36a
Aphids/3 leaves	2019-20	0.1	0.3	0	3.45	3.8	3.2
	2020-21	1.06a	1.08a	1.01b	7.72a	8.12b	7.55a
	2021-22	-	-	-	-	-	-
	Mean	0.58	0.7	0.5	5.5a	5.96b	5.37a

The local checks used were AKA 8 and NDLA 2933 in the central and south zones, respectively. The zonal checks used were AKA 7 and DLSa 17 in the central and south zones, respectively. The entries were evaluated in Khandwa and Akola locations in the central zone and Dharwad and Chamrajnagara locations in the south zone of India. Means with the same letter in the row are not significantly different by t-test.

Table 7. Reaction of varieties NDLA 3116-3 and NDLA 3104-4 to different major diseases compared to local check (LC) and zonal check (ZC) in AIC trials

Traits	Years	Central zone			Southern zone		
		NDLA 3116-3	LC	ZC	NDLA 3104-4	LC	ZC
Bacterial leaf blight	2019-20	3.3	3.3	3.3	0	0	0
	2020-21	3.3a	3.3a	6.7b	0	0	0
	2021-22	-	-	-	0	0	0
	Mean	3.3a	3.3b	5.0b	0	0	0
	AUDPC	4.95	4.9	8.3	-	-	-
Alternaria leaf spot	2019-20	-	-	-	4	4	4
	2020-21	-	-	-	23.9a	20.1b	21.9a
	2021-22	17.9a	20.0b	29.1c	16.8a	13.6b	15.1a
	Mean	17.9a	20.0b	29.1c	14.9a	12.5b	13.6c
	AUDPC	8.9	10.0	14.5	34.3	28.9	31.4
Gray mildew	2019-20	-	-	-	3	2	2
	2020-21	6.7a	5.0b	13.3c	27.3a	26.4b	26.5b
	2021-22	-	-	-	20.7a	20.1a	19.0b
	Mean	6.7a	5.0b	13.3c	17.0a	16.2a	15.8b
	AUDPC	6.7	5.0	13.3	39.1	37.4	37.0
Rust	2019-20	-	-	-	-	-	-
	2020-21	-	-	-	26.4	24.6	25.4
	2021-22	-	-	-	15.6	15.3	20
	Mean	-	-	-	21	20	21
	AUDPC	-	-	-	34.2	32.2	35.4

The local checks used were AKA 8 and NDLA 2933 in the central and south zones, respectively. The zonal checks used were AKA 7 and DLSa 17 in the central and south zones, respectively. The entries were evaluated in Khandwa and Akola locations in the central zone and the Dharwad location in the south zone of India. Means with the same letter in the row are not significantly different by t-test. AUDPC – Area Under Disease Progress Curve.

SEED PRODUCTION AND AVAILABILITY

The varieties NDLA 3116-3 and NDLA 3104-4 were identified with national identity numbers IC650311 and IC650320 by the Division of Germplasm Conservation, National Bureau of Plant Genetic Resources, New Delhi, India. Besides, the Regional Agricultural Research Station, Nandyal, India, will produce the breeder seed of the varieties and make it available to the farmers for commercial cultivation from the 2024-2025 cultivating season.

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DATA AVAILABILITY

The datasets generated and/or analyzed during this research are available from the corresponding author upon request.

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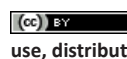
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